Slide #1
In this class we will give a short description of what a Manual J, S and D are and an overview on how to read and interpret a typical calculation submittal. Please contact us for more technical questions.

Slide #2
ACCA (**A**ir **C**onditioning **C**ontractors of **A**merica) Manual J is the calculation method that provides the heating and cooling load for the building and is required in section M1401.3 of the 2009 International Residential Code. The code requirement for a Manual J calculation is not new and has been in the IRC since the 2000 edition. The designer must accurately input the buildings construction features and use the correct inside and outside design parameters. We will show you where design temperatures and construction descriptions (in plain language) can be found in the calculation report that should be submitted to the building department.

Slide #3
ACCA Manual S is the process to select the heating and cooling equipment that will have the capacity to satisfy the calculated loads. This is required in section M1403.1 of the 2009 IRC. 2009 was the first edition the Manual S requirement appeared, but as we will learn a proper residential HVAC design has always included the Manual S equipment selection process. We will show you the clues in the submittal documents if the designer has attempted to select the proper equipment.

Slide #4
ACCA Manual D is the process for calculating the duct size based on the room's load and type of ductwork used. A poorly designed duct system will negate the best load calculation and equipment selection. Manual D is required in section M1601.1 of the 2009 IRC. The requirement for a Manual D design first appeared in the 2003 IRC. We will show you the clues in the submittal documents if the designer has attempted to properly design the duct system.

Slide #5
There are four approved Manual J and two Manual D software available. These are the only software packages that have been reviewed and tested by ACCA and accurately perform the calculations. Notice there is not approved Manual S software. All of the approved Manual J software include equipment selection ability and includes many manufacturers and the equipment capacities. However the equipment selection process (Manual S) has many variables, adjustments and designer preferences for any software. The equipment selection process must be done by the designer and then entered into the software. We will show you the clues in the submittal documents if the designer has attempted to properly select the right sized equipment.

Slide #6
We will use a Wrightsoft report for our example. Remember that all ACCA approved software systems have the same inputs and do all of the calculations the same, however the format of the reports are completely different.
Click: We will start by reviewing the Project summary report and the design conditions.

Slide #7
(Click) First verify that the correct location is selected. Today we will use Denver. There are many times when your exact city is not in the weather data base and a city with like weather

conditions can be selected, or the jurisdiction has a code that states what the outside design temperatures are for their location.

(Click) Then Winter Design Conditions

(Click) Verify the Winter outside design dry bulb (db) temperature. -3 F is correct for Denver

(Click) Verify that the Winter inside design dry bulb temperature is 70 F. A range of 68 F to 72 F is acceptable and will not have a large effect on the calculated loads.

(Click) The Design TD (Temperature Differential) is simply the difference between the outside and inside design temperature. 73 F is correct.

(Click) Now the Summer design conditions

(Click) Verify the Summer outside design dry bulb temperature. 90 F is correct for Denver

(Click) Verify that the Summer inside design dry bulb temperature is 75 F. A range of 73 F to 77 F is acceptable and will not have a large effect on the calculated loads.

(Click) The Design TD (Temperature Differential) is simply the difference between the outside and inside design temperature. 73 F is correct. 15 F is correct for Denver

(Click) Daily Range is the average difference between the daily high and low dry bulb temperatures at a particular location. Most of Colorado will be High (H) which means the temperature swing from the daytime high an the nighttime low is more than 25˚ F.

(Click) Verify the relative humidity and should be set at 50%. Both ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) and ACCA through years of study have defined ‘Comfort’ for people living in their homes as 75˚ F at 50% humidity. Designers may choose to design at 45% relative humidity in Colorado's dry climate. This would be acceptable as this would not adversely effect the cooling load.

(Click) Verify the the Moisture Difference is a negative number. In the dry Colorado climate this will ALWAYS be a negative number. Showing a positive number here WILL adversely affect the cooling load.

Moisture Difference is the difference in grains of moisture per pound of air (gr/lb) from the air outside compared to the air you would like to have on the inside of the house, in our case 50% relative humidity.

(Click) Verifying that these design parameters are correct an important first step in the review process. If these inputs are not correct the rest of the load calculation, equipment selection and duct sizing are wrong.

Slide #8

Click) We will look at the Component Constructions report before returning to the Project Summary report.

(Click) First we will review the design conditions and then

(Click) the Construction descriptions

Slide #9
The design conditions on this report should be the same as shown on the Project Summary report. However this gives us more detail.

(Click) The important design parameter to verify here is the relative humidity for heating load design must be no higher than 30%. Remember we said that comfort for cooling is 75˚ F at 50% relative humidity. Now for heating the relative humidity should not be so high that it would cause visible condensation, like on the inside face of the window. If you can see condensation on the window it is very likely there would be condensation in other areas, like inside wall assemblies and that would not be good. ACCA and ASHRAE have both stated that to avoid visible condensation winter humidity design should not be more than 30%.

Slide #10
This part of the report tells you in plain language how the buildings thermal envelope is to be built.

(Click) The above grade exterior walls in this case are labeled by the software as '12E-0sw' and then describes the wall assembly as ' Frame wall, Wood Exterior, ½" wood Sheathing, R-19 Cavity Insulation, ½" Gypsum Board Interior Finish, 2x6 wood frame' simply verify that the constructions plans indicate the same wall assembly.

(Click) This indicates the net (does not include window or door area) exterior wall area in square feet for this wall assembly type. Verify the square footage with the construction plans. We are looking for general compliance. As we all know we can have three people do a take off from the same plan and get three different area calculations. As long as the numbers are close we should be good to go.

(Click) The below grade exterior walls in this case are labeled by the software as '15B-0sw-0wo-8' and then describes the wall assembly as 'Below Grade wall, light dry soil, 2" x 4" interior frame, Concrete Wall, R-13 cavity insulation, concrete wall, ½" gypsum board interior finish'.

(Click) This again indicates the net (does not include window or door area) exterior wall area in square feet for this wall assembly type. Verify the square footage with the construction plans. We are looking for general compliance.

(Click) Partitions are walls that separate conditioned space from unconditioned space. A good example would be the walls   that separate an attached garage from the house, or the walls that separate conditioned spaces from an unvented attic assembly. The design temperatures in this enclosed but not conditioned space could be and almost always are different than the outside design temperatures. As an example, our outside summer design is 90˚ so what would the temperature be in the attic??? I would say about 120˚ or warmer. This has an affect on the cooling load and the software can calculate this, but the designer must create portion walls in the load calculation.

(Click) This indicates again the net partition wall area. In this example the partition wall is between the unconditioned garage and the house.

(Click) There will be several inputs for the windows based on the window size and any soffit that may shade the window. These windows are labeled by the software as ‘VINYL U 34 SHGC 40’ and then described as ‘Vinyl Clad Low-E window, NFRC (which stands for National Fenestration Rating Council) rated (SHGC=0.40) (which stands for Solar Heat Gain Coefficient) ; 50% blinds at 45˚, medium color, 50% outdoor insect screen; with a 2’ overhang (3’ window Height, 2’ separation) which means the window is 3’ tall and there is 2’ from the top of the window to the bottom of the soffit. Designers must include all overhangs and include some type of shade and insect screens. All of these items shade the windows and has a large impact on the cooling load. There will always be some windows that have no overhang, shades or screens (like the large picture window that face West) the point here is that most of the windows will have some type of shading.

(Click) This row shows the U value for the assemblies. This is where you will verify that the window U values match the constructions plans.

(Click) This row shows the insulation R value of the assemblies. This is where you will verify that the wall R values match the constructions plans.

Slide #11
We will now go back to the project summary report and look at:

(Click) The Heating Summary

(Click) Infiltration Loads

(Click) The Heating Equipment Summary

(Click) The cooling loads, Sensible and Latent

(Click) The Cooling equipment Summary

Slide #12
Now that we know the indoor and outdoor design temperatures and the construction assemblies are correct we can review that calculated loads.

Click: This is the calculated heat loss for the structure (walls, floors, ceilings, etc.) is 28,273 Btuh

Click: This is the duct loss. You would only see a loss if the ducts were located outside the buildings thermal envelope, like ducts installed in a vented attic assembly. Our example today has all of the duct work located inside the buildings thermal envelope.

Click: This value is used to calculate the occupant ventilation requirement, which is used to calculate the Central Supply Ventilation AVF. You may need to override this value to comply with local building codes. Manual J8 calculates the central ventilation load as the outdoor air requirement less the summer infiltration AFV. The outdoor air requirement is calculated as the largest of 3 values:

1. General ventilation 0.35 x above grade volume of conditioned space/ 60
2. Occupant ventilation Minimum ventilation per person x Number of occupants (The software defaults to 20 CFM per person)
3. Combustion air requirements 0.50 x input capacity of furnace with atmospheric burner/1000

Solve for today's house

Click:

1. .35 x 14,464/60 = 84
2. 20 x 5 = 100
3. 0.50 x 40,000 / 1000 = 20

100 cfm – 36 cfm = 64 cfm

Click: Humidification will add to the heating load. Remember we checked to make certain that the heating design for inside humidity was no more than 30%? This is where you would see the load if a humidifier was included in the design. In our case a humidifier was not party of the design. If the designer had included a humidifier and set the design for more than 30% the load here would be higher than needed.

Click: This would be the heat loss for piping and would only show up if this were a hydronic system.

Click: Equipment load is the total load on the equipment. The next step is to verify that the designer has selected a piece of equipment that will satisfy the load without being oversized.

Click: Infiltration method the designer is using is simplified. All Manual J software has the ability to calculate the infiltration load for each room based on each room's infiltration rate. This can be very complicated and many times the builder and designer do not know what infiltration rate will be for each room. Many times designers will use the simplified method based on a construction quality and use the same infiltration rate for all rooms.

Click: There are 5 Construction quality choices from tight to loose. Using the average is a good place for designers to start, even if the builders construction technics are unknown, today's construction practices will produce a home of average tightness. So average construction means that during the heating season the natural ACH (Air Changes per Hour) .28. This means that each hour 28% of the above grade volume of the home is being replaced with air leaking through the walls. The reason there are two different infiltration rates is that winter infiltration is done with a 15 MPH wind and summer is done with a 7.5 MPH wind.

Click: Fireplaces would be included in the design (for infiltration purposes) if the fireplace was a open hearth type. Many gas fireplaces today are direct vent type and are very air tight.

Click: Area is the entire conditioned area in square feet.

Click: Volume is the above grade volume in cubic feet. The example house today is a Ranch style with a full standard basement, meaning not a garden level or walkout basement. The infiltration through a concrete wall that is below grade is negligible. If this design included basement walls that were above grade (like a walkout) then volume would change.

Click: Equivalent AVF (Air Volume Flow) is the amount of air coming through the walls at the selected construction quality in cubic feet per minute.

Slide #13

This is as close to a Manual S any software gets. Remember the software has no clue how to size the equipment the designer must adjust as needed in the software. In our example we are using a gas fired forced air furnace at 5000' above sea level. ALL manufacturer's performance data is performance at SEA LEVEL and must be adjusted for altitude. An adjustment for altitude is needed for all appliances used above 2000'.

Click: The software has a large data base of basic information on a large number of equipment manufacturers. The Make, Model, Gamma ID, Efficiency and Heating input are generally correct.

Click: The heating output must be adjusted by the designer. The software will adjust for efficiency, in this case 92.1%, but not for altitude. Each manufacturer will have their own de-ration for altitude, for Carrier it is 2% for each 1000' above sea level. This information will be in the manufacturers expanded performance data that should be part of the plan submittal. I will show you a portion of the performance data in the next slide. So one clue to you the plans examiner is did the designer adjust for altitude or not?

Click: Here is the math adjusted for efficiency only 40,000 x .921= 36,480. Now for those that are reviewing if this report showed 36,480 Btuh as the heating output, you know the designer did not adjust for altitude correctly and the selected

Click: and now for altitude x .9 = 32,156 Btuh Remember the altitude adjustment for Carrier was 2% per 1000' of elevation so 5000' = 10% reduction.
Click: Temperature rise range is again from the manufacturer's performance data. We will show the example on the next slide. This is another quick check for the person reviewing, if the Heating output or the Actual Air flow was not adjusted by the designer the heat rise will not be within the correct range.

Click: The Actual Air flow is from the manufacturer's performance data at a specified static pressure. On the next slide we will show you where in the performance data this can be found.
Click: The Air flow factor is calculated by the software and will be correct if the Actual Air flow has been entered correctly.

Click: Static pressure is what the designer has used for total system static.

If any of these areas are blank, the designer has not correctly selected the heating equipment.

Slide #14

In the specifications for the Carrier 58MCB furnace we find the certified temperature range to be 15-45° F. The design was at 44° so this will work. Many designers will prefer to be in the middle of the temperature rise range. In this case increasing the fan speed will lower the temperature rise.

Slide #15
This is a partial section of the air delivery chart.

Click: Setting the heat speed on Med-low at .7 total external static pressure shows the blower will move 830 cfm of air. This should match what the designer used in the design and it does.

Click: The designer could have the next higher fan speed Med-High for 930 cfm of air and would have lowered the temperature rise. Either would work as long as the design matches the furnace blower capabilities.

Slide #16

Sensible Loads are:

The heat gain of the home due to conduction, solar radiation, infiltration, appliances, people and pets. Burning a light bulb, for example, adds only sensible load to the house. The sensible load raises the dry-bulb temperature.

Click: This is the calculated heat gain for the structure.

Click: This would be the duct load if any of the ductwork was located outside the buildings thermal envelope. Check the plans if the ducts are outside then there should be a load here.

Click: Central vent is the sensible load from the ventilation calculation we did on the heating side.

Click: Blower is the sensible load the furnace blower motor has. It is not unusual to see a small load here 500 Btuh to 2000 Btuh on the high side. Some designers add this load others do not, either would be correct.

Click: Use manufacturer’s Data should be ‘Y’ (Yes). This is one of this software's attempts to size the equipment. If the designer leaves this as a ‘N’ (no) then the Rate/swing multiplier

Click: adjusts the calculated load by some unknown factor. When Yes is selected by the designer you know two items: 1. The designer knows the software has no clue how to select equipment and has changed the default of no to yes and 2. You know the calculated sensible load without any adjustments.

Click: In this example 16, 613 Btuh.

Slide #17

Latent Load

The net amount of moisture added to the inside air by people, plants, cooking, infiltration and any other moisture source.

Click: This is the latent load for the structure 274 Btuh

Click: There would be the latent duct load if the duct were located outside the buildings thermal envelope.

Click: Central vent is the ventilation air we calculated in the heating section. This is the latent load. This number in Colorado will ALWAYS be negative. Colorado is VERY dry and does not have a calculated latent load.

Click: The total Equipment latent load is zero and will always be zero for Colorado.

Click: The equipment total load for or example is 16, 613 Btuh. There are 12,000 Btu's per ton of air conditioning. So the calculated load is about 1.3 tons

Click: Required total Capacity at 0.85 SHR. SHR is the Sensible Heat Ratio. This is the ratio of sensible load to total load. To calculate the SHR you divide the sensible load by the total load.

Click: So the math of our example house would be 16, 613 / 16,613 = a SHR of 1.00. So now the question, why does the report say 0.85 SHR????? This is another area where this software attempts to 'guess' how the equipment may perform. We just showed you that the calculated load is about 1.3 tons, now suddenly the required equipment capacity needs to be 1.6 tons? Yes the software just made the air conditioner 15 % larger just because. This SHR entry can be changed by the designer to whatever value they want. Do not be fooled by designers that insist that the 'software' requires a 1.6 unit. No the actual load is 1.3 tons. Just to let you know the software default for this is 0.70 (yes it appears the designer changed it) and would have shown the required capacity at 1.8 tons… WOW

Slide #18

The cooling equipment selection can be a bit tricky, we will point out a few clues that indicate the designer actually made the proper adjustments.

Click: The Make, Trade, Condenser (outdoor unit), Coil (coil on top of the furnace), ARI reference number and the efficiency are all in the software data base and are generally correct. These could be changed by the designer but there is not an advantage to do so.

Click: The Sensible, Latent and total capacities can be compared with the equipment performance data that should be part of the submittal package. On the next slide we will show an example and what to look for.

Click: The Actual Air flow again is from the manufacturer's performance data. The same one we looked at for the heating air flow. We will show an example on the next side.

Click: The air flow factor is calculated by the software and as long as the calculated cooling load is correct (and for the example it is) and the Actual Air Flow number is correct (which will see it is for the example) the Air flow factor is correct. The calculated room cooling load times the air flow factor equals the need CFM to that room.

Click: The Load sensible heat ratio.. Remember on a previous slide we determined that the sensible heat ratio was 1.00? This is where in this software program the designer cannot change the answer. The software does exactly the same math we did. Cool stuff!!! OK so maybe only cool to geeks like us….

Slide #19

You will be expecting the expanded performance data with the Manual J submittal. The title should match what the report indicated.

Click: In this a 24ABA3 is correct.

Click: The performance data will contain page after page of detailed performance data. We strongly suggest that you have the designer identify the exact page and air speed they used for their equipment selection. This is a partial piece of one page.

Click: The sheet will have a title like this 'Detailed cooling capacities'

Click: The sheet will indicated the outdoor condenser and the indoor coil model numbers. In this case they match our example.

Slide #20

So hopefully the designer has indicated the capacities used for their selection like we have.

Click: The EWB (Entering Wet Bulb) must be either 62° or 63° depending on the performance data. Remember our inside design was 75° at 50% relative humidity, that is equal to a 62° wet bulb.

Click: The air entering the outside condenser must be within 5° of the outside design temperature. In our example the outside design is 90°, so the 95° column works.

Click: Now look at the total and the sensible capacities. They are both the same at 21, 350 Btuh.

Click: There are many adjustments the designer may need to make based on the manufacturer and how the performance data is presented. All of these adjustment factors are in the performance data foot notes. One clue that designer made the adjustments is in the report you see the total capacity is the same and it should match. Also the sensible capacity in the report is not the same as the performance data and it should NEVER match.

Slide #21

The next big clue is that the CFM in the performance data and the report should never match. Remember all of the performance data is for performance at sea level. So an adjustment is needed for altitude. This is generally done with the air speed. Air at altitude is less dense so you need to move more air at altitude to get the same performance you would have at sea level.

Click: Bottom line for the plans examiner; The actual air flow on the report will always be higher than the CFM on the performance data.